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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the Federal Communications Commission
Washington, D.C. 20554

92-125

In the Matter Of

Amendment of the Aviation Services Rules)
(Part 87) to authorize use of the frequency)
406 MHz for Emergency Locator Transmitters (ELTs))

RM 7611

COMMENTS OF SARSAT OPERATIONS DIVISION OF THE NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE (NESDIS), NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration (NOAA), through the SARSAT Operations Division of NESDIS, as the US Agency responsible for operational control of the SARSAT satellites, provides its comments on the subject Notice of Public Rulemaking (NPRM).

NOAA supports the authorization of 406 MHz for Emergency Locator Transmitters (ELTs). The comments contained herein are intended to respond to the issues raised by the FCC in the subject NPRM and to highlight and amplify the NOAA position put forth in its Petition to the FCC dated 10 January, 1991.

I. BACKGROUND

NOAA serves as the lead agency in the U.S. Interagency Program Steering Group (PSG) which brings together all of the US federal agencies having a direct responsibility to operate and utilize the COSPAS/SARSAT satellite system. NOAA provides the chairman for the PSG and the representative to the International COSPAS/SARSAT Council (CSC). The CSC is the management entity for the international satellite system and is formed by the providers of the COSPAS/SARSAT space segment.

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NOAA is responsible for the U.S. portion of the SARSAT space segment as well as the provision and operation of the ground segment including the Mission Control Center (MCC), the ground stations (Local User Terminals) and the associated communications and test facilities.

II. Response to specific issues raised by the FCC in the subject Notice of Public Rulemaking (NPRM)

(1) 121.5 MHz Homing Signal The 121.5 MHz homing signal is necessary because it provides rescue personnel with the ability to pinpoint the distress transmission for the final phase of the search and rescue (SAR) operations. The accuracy of location of the 406 MHz satellite system is approximately 2 km and the 121.5 MHz homing signal is necessary for the final phase of the rescue operation. SAR forces are currently equipped with 121.5 MHz homing equipment, and the option of homing on 406 MHz is not now a practical alternative because of the lack of experience of homing on a burst signal (1/2 second burst every 50 seconds) and the delay and cost such an operational transition would create.

(2) Additional International Requirements not in RTCA Standard To our knowledge the only international requirement that is not in the Radio Technical Commission for Aeronautics (RTCA) standard is the requirement for certification by a COSPAS-SARSAT approved test facility. This requirement is discussed in our response to the third issue raised by the FCC in the NPRM.

(3) Requirement for Independent Laboratory Certification On behalf of the US government the NOAA Administrator signed an Intergovernmental Agreement on 1 July 1988 to furnish operational satellites for a period of 15 years and to cooperate with its international partners in sustaining the operation of the system. The SARSAT Operations Division of NOAA NESDIS is responsible for carrying out the responsibilities of the US under this Intergovernmental Agreement and represents the US on the COSPAS-SARSAT Council, the governing body charged with carrying out the terms of the Agreement. Under the Agreement the US has pledged to abide by the technical standards adopted by the COSPAS-SARSAT Council (CSC).

These standards[1] require certification of beacons by an approved COSPAS-SARSAT test facility to ensure compatibility of the beacons with the satellite system and to protect the integrity of the 406 MHz SAR system. If beacons were placed in operation in the US without this certification it would not only violate the Intergovernmental Agreement, but it could also result in incorrect data being furnished to the SAR forces and in some cases (e.g. failure mode with transmitter on continuously) could prevent other distress signals from being received.

(4) Effectiveness of Voluntary Registration NOAA has analyzed the 406 MHz distress alerts currently being received and it is estimated that only 50% of the 406 MHz Emergency Position Indicating Radio Beacons (EPIRBs) in use today have been registered in the NOAA Data Base. A check with manufacturers of electronic equipment indicates that their experience with voluntary registration is even lower; between 10 to 25%. Lack of data in the NOAA data base can seriously impact the effectiveness that would be available from the use of 406 MHz ELTs. This lack of information when a distress alert is received through the COSPAS-SARSAT system can delay the launch of rescue forces, can deprive the rescue forces with valuable data on the type of craft in distress and can cause a misuse of rescue forces that are launched for false alarms.

Although it is difficult to document the exact extent of delays that are incurred when registration data is not available in the real distress cases it is evident that resources required to handle false alarms will impact the response of rescue personnel. In addition, the availability of contact points in the data base can often hasten the decision to launch a mission by determining the probability that a distress has occurred.

Valuable SAR resources are saved when the 406 MHz beacons are registered in the data base. US Coast Guard experience with 406 MHz EPIRBs has shown that in 82% of the false alarm cases generated by a 406 MHz beacon the case can be closed by telephone contacts without requiring that a SAR mission be launched. On the other hand, when the beacon is not registered it requires the launch of SAR forces in 80% of the false alarm cases.

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[1] COSPAS-SARSAT Document C/S T.007 C-S 406 MHz Distress Beacon Type Approval Standard

An additional benefit of the 406 MHz system is the use of geostationary satellites to detect signals from 406 MHz emergency beacons. Because of the lack of Doppler data at geostationary altitude the system cannot provide location of the distress transmitter unless the location data is provided in the beacon message by some means such as an on-board navigation system. This type of beacon message with location data is expected to be the exception rather than the rule because of the increased complexity and cost it adds to the ELT and its installation.

Lacking either the insitu location information or data in the NOAA data base, the Rescue Coordination Center (RCC) cannot take any action with a geostationary alert until a low orbit COSPAS-SARSAT satellite has provided a location to the RCC. This delay can be up to 2 hours in the US mid-latitude regions and even greater in Hawaii and portions of the South Pacific. On the other hand, experience has shown that the ability to use the data base when a geostationary alert is received can result in almost immediate action by rescue forces due to information provided by the points of contact contained in the data base.

The 406 MHz geostationary system has been demonstrated and is in partial operational use today. The next generation of geostationary environmental satellites planned for launch by NOAA in 1993/1994 will carry a 406 MHz repeater to provide full operational service over the US areas of interest. The use of this capability in a fully operational mode can make a dramatic improvement in rescue operations if the ELTs are registered in the NOAA data base. Almost immediate detection of the distress, followed by validation of the emergency and determination of the approximate location from the points of contact, will allow rescue forces to take immediate action to launch a rescue effort.

III. The Advantages of 406 MHz ELTs over 121.5/243 MHz ELTs

The NOAA Petition to the FCC dated 10 January 1991 requested FCC to grant approval for the use of 406 MHz ELTs in the US aviation community. The NOAA petition outlined the primary advantages that 406 MHz ELTs offer to the US flying public. These advantages are herein summarized and by reference the NOAA Petition to the FCC dated 10 January 1991 is included in our response to the subject NPRM.

The primary advantages that 406 MHz beacons offer are:

- Elimination of Frequency Interferers - About 92% of first alerts received by the 121.5/243 MHz satellite system are caused by radiation from sources other than a valid emergency beacon or by noise generated within the system. This large number of false alerts[2] results in an extensive effort by the RCCs to cope with these false alerts as well as with false alarms[2] and can hamper and delay rescue efforts in real distress cases. The incorporation of an encoded identification within the 406 MHz transmission virtually eliminates false alerts from the satellite system.

- Identification of the Aircraft in Distress - All 406 MHz emergency beacons transmit a coded signal which identifies the beacon and enables access to owner and aircraft identification through a beacon registration data base maintained by NOAA. This identifies the search objective for the SAR forces, provides a means of validating that a distress has occurred and in most false alarm cases allows handling of the report without launching a SAR mission.

- Resolution of Ambiguous Location - The ability of the 406 MHz system to resolve the location ambiguity on the 1st pass of a satellite saves, on the average, 1 hour which is lost by the 121.5/243 MHz system in waiting for the second pass to resolve the ambiguity.

- Potential for Immediate Alert Using a 406 MHz Geostationary System As discussed above the use of a geostationary capability to immediately detect 406 MHz alerts offers a dramatic improvement in the US rescue system. This capability cannot be implemented at 121.5/243 MHz because of the low power from these transmitters and lack of coded information in the signal structure.

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[2] A "false alert" is a location generated by the COSPAS-SARSAT system from other than distress transmitters. They are generated by other RF signals in the band or from noise. "False alarms" are signals from ELTs or EPIRBs that are generated in non-distress situations such as mishandling of the beacon.

- Greater Location Accuracy - The 406 MHz system provides a location accuracy of 2-5 km vs. the 15-20 km accuracy normally achieved with 121.5/243 MHz beacons.

- Global Coverage - Because of the beacon coding in 406 MHz ELTs the data can be received and stored by the satellite on a world wide basis. The limitations inherent in the 121.5/243 MHz system do not allow processing and storage on-board the satellite, therefore, if a ground station is not in view where the distress incident occurs it will not be reported. This leaves large gaps of coverage over parts of the globe not covered by a COSPAS-SARSAT Local User Terminal (LUT).

- Satellite System Capacity - The 406 MHz satellite system can accommodate up to several hundred simultaneous alerts even when some of the transmitters are in the same location. This capacity will allow for virtually unlimited expansion of the system without the danger of overloading the system. Because of the continuous transmission of 121.5/243 MHz beacons and the extent of interference from other sources in those bands, the system is currently near saturation in times of high activity. Further expansion of the number of users of 121.5/243 MHz beacons could cause serious problems.

A NASA study completed in 1990[3] projected a saving of 25 lives a year due to the improved survivability of ELTs built to the Radio Technical Commission for Aeronautics (RTCA) new standard, DO-183, versus the current ELTs in the field built to the old RTCA standard, DO-147 (the new standard has not yet been applied to the requirements for carriage of ELTs). All of these improvements are incorporated in the 406 MHz ELT RTCA Standard.

To determine the benefits that would accrue in addition to the benefits from the new 121.5/243 MHz standard, NOAA initiated a study of the advantages of 406 MHz ELTs and how those advantages translate into benefits. This "Delta Study" has recently

[3] NASA Contractor Report 4330 entitled "Current Emergency Locator Transmitter (ELT) Deficiencies and Potential Improvements Utilizing TSO-C91a ELTs", October 1990

been completed and is currently in review.[4] A copy of the Draft Report is included as Attachment 1.

The results of the NOAA study indicate that the 406 MHz ELTs have a potential of saving an **additional 9 lives per year** as well as **saving an estimated $5.4 million per year** in SAR operating costs for handling false alarms in the US inland area.

The benefits to be obtained from the use of 406 MHz ELTs were derived from three areas: 1) improved survivability; 2) reduction in the SAR timeline; and 3) improved handling of false alarms.

1) Improved Survivability A paragraph by paragraph comparison was made between the specification requirements contained in RTCA DO-183 (121.5/243 MHz ELTs) and DO-204 (406 MHz ELTs) and the improvements/changes made in DO-204 were noted. It was concluded that the DO-204 specification improvements would have an impact in three areas: Fire Damage, Impact Damage and Internal Failure. Review of previous data examined in the NASA study, and the considered opinion of a panel of experts resulted in an estimated survivability of the 406 MHz ELT of 81% vice the 75% projected for the DO-183 121.5/243 MHz ELTs.

2) Reduction in the SAR Timeline Three months of mission folders (484 missions) from the Air Force RCC (AFRCC) were analyzed to develop a baseline for detailed analysis of the current mission timeline for 121.5/243 MHz ELTs. The intent of this portion of the study was to estimate the reduction in the SAR timeline due to the advantages of the 406 MHz ELT and convert this time reduction to increased survivability. The resolution of location ambiguity from the first satellite pass; the improvement of decision making ability on launching a rescue mission; and the reduction in search area by a factor of 10; results in an estimated average saving of 6.1 hours in the search timeline. It was estimated that an additional average time saving of 1 hour would result from the geostationary system when the beacons were registered in the NOAA data base.

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[4] NOAA Draft Report "406 MHz Delta Study: Additional Advantages of 406 MHz Emergency Locator Transmitters (ELTs) over TSO-C91a 121.5/243 MHz ELTs" dated 9 June 1992.

3) Improved Handling of False Alarms It was assumed that the number of false alarms would remain unchanged from present operational experience. Problems with false alarms will be mitigated due to the greater ease of handling the 406 MHz alerts. The features in the 406 MHz system which will lead to mitigation of false alarms are: identification in the message and the improved accuracy of location.

Identification in the message will allow the RCC controllers to know the type of vehicle (e.g. aircraft or ship) and when the I.D. is registered in the data base will allow communications checks with the owner, home airport or other points of contact to determine if an emergency exists. The registry will also show the type of aircraft and give an indication of the number of people that may be involved such as in an airliner or a small private plane.

The accuracy of location (within approximately 2 Km) will be of particular help when the data base information is not available or in error. This accuracy should allow the RCC to contact the particular airport, if the plane is on an airport, or send someone directly to the scene.

IV Summary and Recommendations

The 406 MHz EPIRBs have provided a dramatic demonstration of the effectiveness of the 406 MHz system in the maritime area. Over 100 lives were saved with the 406 MHz EPIRB during the last six months of 1991. In January 1992 alone, 42 lives were saved with this system. The effectiveness of the 406 MHz system, when beacons are registered in the data base, has been shown to save launching a SAR mission in over 80% of false alarm cases. For the reasons documented in this letter and the attached "Delta Report" NOAA considers it imperative that the FCC authorize the use of 406 MHz ELTs by the US aviation community.

Regarding the questions raised by the FCC in the subject NPRM, the following recommendations are made:

1. A 121.5 MHz homing signal should be included with the 406 MHz ELT.

2. Testing by an approved COSPAS-SARSAT test facility should be required.

3. Mandatory registration of 406 MHz ELTs should be included in the rulemaking.

For the SARSAT Operations Division, NESDIS,
National Oceanic and Atmospheric Administration

James T. Bailey, Division Chief

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NOAA
DRAFT REPORT

9 JUNE 1992

406 MHz DELTA STUDY: ADDITIONAL ADVANTAGES OF 406 MHz EMERGENCY LOCATOR TRANSMITTERS (ELTs) OVER TSO-C91a 121.5/243 MHz ELTs

**SARSAT OPERATIONS DIVISION
OF THE
NATIONAL ENVIRONMENTAL SATELLITE, DATA,
AND INFORMATION SERVICE (NESDIS),
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION**

DRAFT

406 MHz DELTA STUDY: ADDITIONAL ADVANTAGES OF 406 MHz EMERGENCY LOCATOR TRANSMITTERS (ELTs) OVER TSO[1]- C91a 121.5 MHz ELTs

1 INTRODUCTION

1.1 SCOPE AND PURPOSE

This study examines the benefits to search and rescue of the 406 MHz ELT when used with the COSPAS-SARSAT system. These benefits are then compared to the benefits expected from the 121.5/243 MHz ELTs built to TSO-C91a (RTCA DO-183) based upon the NASA study conducted for the FAA.[2] The benefits over and above those expected from the TSO-C91a ELTs are then derived based upon this comparison.

1.2 SYSTEM OVERVIEW

The COSPAS-SARSAT system receives and processes signals in three frequency bands: 121.5 MHz, 243.0 MHz[3], and 406 MHz. For 121.5 and 243.0 MHz data, the Doppler-shifted frequency is placed on the satellite downlink and transmitted back to earth in real time (no processing is done on the satellite). For 406 MHz transmissions, spacecraft equipment measures the Doppler-shifted frequency and detects the ELT digital data message. The data is time tagged and stored in the spacecraft as well as being transmitted in real time to earth stations that may be in view. Thus real-time 121.5 /243.0 MHz data and 406 MHz data may be received by an earth station within view of the satellite, however, only the 406 MHz data provides coverage when the satellite is not in view of a ground station.

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[1]Technical Standard Order (TSO) = term used by FAA to denote technical requirements for aeronautical equipment

[2] NASA Contractor Report 4330 entitled "Current Emergency Locator Transmitter (ELT) Deficiencies and Potential Improvements Utilizing TSO-C91a ELTs", October 1990

[3] COSPAS satellites do not receive the 243 MHz frequency.

2 ADVANTAGES OF THE 406 MHz SYSTEM

2.1 ELT TRANSMITTER IMPROVEMENTS

The 406 MHz ELT Transmitter improvements resulting from the application of RTCA DO-204 are:

- Improved Survivability
- Higher Power Transmission
- A Built-in Self Test Requirement
- Both Aural and Visual Monitors

2.1.1 Improved Survivability

Examination of Table 7, Page 12 from the NASA ELT Study[4] reveals that a large number of failures will still occur while utilizing TSO-C91a ELTs. Specifically the failures due to fire, impact damage, and internal failures are predicted to account for 345 out of the remaining 481 expected failures. The specific improvements (in addition to the TSO-C91a specification) required by the 406 MHz ELT specification are:

- Additional Shock Tests While the ELT is Operating
- The ELT is Required to be Operating During the Protrusion and Pressure Survival Tests
- Some Fire Survival Tests are Required (TSO-C91a has none)
- More Stringent Temperature Soak Test
- Additional Thermal Shock Endurance Test
- Adds Decompression Requirement Simulating Actual Operating Conditions
- Adds Requirement to Ensure Waterproof Enclosure After Replacing Battery

2.1.2 Higher Power Transmission

With an output power of 5 watts (vs. 75 milliwatts for the 121.5/243 MHz ELTs) the 406 MHz ELTs provide a greater reception margin to the COSPAS-SARSAT low orbiting

[4] NASA Contractor Report 4330 entitled "Current Emergency Locator Transmitter (ELT) Deficiencies and Potential Improvements Utilizing TSO-C91a ELTs", October 1990

satellites, which, under some conditions of a crash, could mean the difference between detection and non-detection of the distress signal. The higher power also allows detection through geostationary satellites.

2.1.3 <u>A Built-in Self-test Requirement</u>

The built-in self-test feature should detect failures that could cause the ELT to fail to function during and after a crash. Corrective action, such as replacing a battery or tightening a loose connection, could then be taken. This feature will reinforce the survivability advantages of the TSO-C91a requirements and accrue the advantages resulting from preventative maintenance that are indicated in the referenced Table 7 of the NASA study.

2.1.4 <u>Both Aural and Visual Monitors</u>

TSO-C91a only requires an aural or visual monitor in the cockpit to alert the pilot that the ELT transmitter has been activated. Generally the visual monitor is employed as a standard feature. The audio monitor would complement the visual monitor and insure early detection of the ELT, especially when no one is in the plane and ground personnel need to find the location of the inadvertent transmission. Early discovery by the pilot or airport ground personnel of an inadvertent turn-on of the ELT will help to mitigate many of the false alarms as well as eliminate some of the dead battery problems.

2.2 SYSTEM ADVANTAGES

The 406 MHz Emergency Locator Transmitter has a number of significant system advantages over the 121.5 MHz or 243.0 MHz ELTs. These advantages are:

- Identification Contained Within the Message
- Greater Accuracy of Location
- High Probability of Ambiguity Resolution on First Satellite Pass
- Global Coverage
- Capability of Detection From Geostationary Satellites
- Greatly Increased System Capacity
- 406 MHz Band Allocated for Satellite-aided Search & Rescue

2.2.1 <u>Identification Contained Within the Message</u>

One of the main advantages of the 406 MHz system is its capability to transmit and detect a digital data message. The digital message contained in the 406 MHz beacon transmission can provide Rescue Coordination Centers (RCCs) with identification data, nationality, type of user, and various other options such as type of emergency, etc. Among the many improvements in rescue operations that accrue from identification, the following are significant to both improving rescue response and reducing SAR forces workload:

1. The ability to determine that the signal is coming from an ELT or EPIRB and not an interfering source. A large number of 121.5/243 MHz incident locations generated by the COSPAS-SARSAT satellite system are generated by RF radiation from sources other than ELTs or EPIRBs.

2. When the beacon is registered in a data base the RCC is able to immediately start communications cross-check with the owner and/or home airport to determine if an emergency exists. False alarms can be dealt with quickly and in many cases this will save the launching of SAR forces. In real distress situations this will enable earlier launch of the SAR forces.

3. Multiple distress messages in the same area can be dealt with more easily than 121.5/243 MHz messages which have no precise way of segregating one case from another.

4. The digitally encoded message allows the detection of 406 MHz ELT/EPIRB signals from geostationary satellites which provides nearly immediate notification to the RCC when a beacon is activated.

2.2.2 <u>Greater Accuracy of Location</u>

The improved oscillator stability of the 406 MHz ELT results in a significant improvement in accuracy. Results of controlled engineering tests during the COSPAS-SARSAT Demonstration and Evaluation Phase (D&E)[5] show better than a ten-fold improvement in accuracy when compared to the 121.5/243 MHz location results (85% less than 2 Km vs. 68% less than 20 Km). Further improvement in location is enhanced in merging multiple pass data using the ID information.

2.2.3 <u>High Probability of Ambiguity Location on First Satellite Pass</u>

The improved oscillator stability of the 406 MHz ELT allows resolving the ambiguity of location on the first satellite pass with a high probability of success. Data taken during the D&E showed the ambiguity resolved more than 95% of the time. This factor alone

[5] COSPAS-SARSAT PROJECT REPORT, AUGUST 1984, page 4-4 through 4-7.

will save in the order of 2 hours in the rescue timeline.

2.2.4 Global Coverage
The digitally encoded format and greater power of the 406 MHz ELT allows processing and storage of the messages on-board the satellite, which provides complete global coverage. Thus, a plane carrying a 406 MHz ELT will have the ability to be detected and located anywhere on the earth. This is not true in the case of the 121.5/243 MHz signals which are only relayed through the satellite, requiring a ground station (Local User Terminal-LUT) to be in view of the satellite when a distress message is sent.

2.2.5 Capability of Detection from Geostationary Satellites
Because of its digitally encoded transmission and the higher power of transmission, the 406 MHz ELT can be detected through geostationary satellites. (The 121.5/243 MHz ELTs can only be detected by the low orbit COSPAS-SARSAT satellites.) A limited geostationary operational capability is already in place and a fully operational system should be available within a few years. With location data in the message and/or when the ELT is registered in the data base, the RCC can begin immediate actions to validate the emergency and launch rescue forces.

2.2.6 Greatly Increased System Capacity
The 406 MHz ELT transmits a burst message of approximately 1/2 second every 50 seconds. Through a combination of frequency spreading and random time sharing of the spectrum, the capacity of the 406 MHz satellite system can accommodate hundreds of distress signals within the field of view of the satellite. The continuous transmission and narrow frequency spectrum of the 121.5/243 MHz ELTs limit the capacity of that system to current usage, thus not allowing for any substantial growth in the number of users.

2.2.7 406 MHz Band Allocated for Satellite-aided Search & Rescue
The 406 MHz ELT was specifically designed to take advantage of the satellite detection system. The use of the band from 406.0 to 406.1 MHz has been assigned by the International Telecommunications Union (ITU) Radio Regulations, Nos. 649 and 2998A. These regulations limit the band to low-power, satellite emergency locator transmitters/beacons. Because the frequency spectrum is exclusively allocated for emergency transmitters, once existing sources of interference are being eliminated and the band should be almost free from interference in the future. Even though there is

currently some interference in the band, interfering transmitters do not produce locations to the RCCs as in the case of 121.5 MHz because of the ID feature in the distress messages.

3 OPERATIONAL ADVANTAGES OF THE 406 MHZ SYSTEM

A fully successful search and rescue (SAR) operation can be viewed as one in which everyone that survives the distress is recovered alive and in the least amount of time. The percentage of survivors who continue to survive after an aircraft accident decreases with the passage of time. According to a Department of Transportation paper,[6] less than 60% of the initial survivors would still be alive when recovered 8 hours after the distress. The number of survivors still alive dropped to approximately 20% when recovered 32 hours after the distress. After 128 hours, the number of survivors approached zero. The sooner that rescue workers can reach a distress site, the more likely it is that they will find and recover survivors. How to reduce this time is a major concern of search and rescue organizations world-wide. The 406 MHz ELT has definite advantages when used with the COSPAS/SARSAT system and can provide significant reductions in the time between accident occurrence and arrival of the rescue forces at the distress site.

A typical SAR operation normally progresses through five stages: notification, evaluation, transit, search, and recovery. The notification stage begins with the aircraft crash and ends when the RCC is notified of the crash or when the aircraft is reported overdue. The evaluation stage begins when the RCC is notified and ends when the mission is opened and rescue forces are en route to the search area. The transit stage begins when the resources depart for the search and ends when the resources arrive in the search area. The search stage begins when the resources arrive in the search area and ends when the crash site and/or survivors are located. The recovery stage begins when rescue forces have located the survivors and ends when the survivors are

[6] DOD & NSC data given in C. Mundo, L. Tami & G. Larson, Final Report Program Plan for Search & Rescue Electronics Alerting and Locating System, DOT-TSC-73-42, February 1974.

enroute to a medical facility.

Two of these five stages, the transit and recovery stages are independent of factors which can be influenced by the COSPAS-SARSAT system. The transit stage is strictly a function of the distance between resource location and search area, while the recovery stage is a function of terrain and climatic conditions. The three stages which can be influenced by the COSPAS-SARSAT system are: notification, planning/evaluation, and search. The following discussion, therefore, is limited to these three stages.

3.1 NOTIFICATION STAGE

Before a SAR operation is initiated, there must be some notification of a distress situation. In the aviation community, notification of a possible distress is received when the aircraft fails to land at its destination or when the COSPAS-SARSAT satellite system detects and locates the aircraft's ELT signal.. Depending on the type of flight plan and destination airfield, hours can elapse between the time the aircraft crashes and when the aircraft is reported overdue. Table 3-1 shows the average time lapse from the last known position (LKP) of the aircraft to when the RCC was notified of a possible distress. Even when the aircraft had a working ELT, there was a delay in excess of 4 hours between the time of the last known position and when the AFRCC was notified (Since there is no data for the time between actual crash and AFRCC notification, the best indication of elapsed time is the time from LKP to AFRCC notification).

Table 3-1 AFRCC Aircraft Missions

	Avg Time (Hours) from LKP to RCC *	
Year	ELT Worked	ELT Didn't Work
1984	8.72	13.25
1985	4.67	20.21
1986	5.15	14.21
1987	4.3	6.2
1988	.53	14.31
1989	5.0	7.9
Average**	5.57	12.34

* Source: AFRCC Annual Reports (1984 - 1989)

** 1988 data left out of average computation due to apparent error in data (.53)
As the table shows, there is a significant difference in notification time when the ELT worked and when the ELT didn't work. When the ELT works, the average time from LKP to AFRCC notification is 5.57 hours. When it doesn't, the average time is 12.34 hours. Unfortunately, as the NASA study determined from NTSB data, only 25% of the ELTs currently in the field work in a crash.[7] The study also projects an improvement to 74% if TSO-C91a ELTs are in use and an even greater improvement can be expected from the 406 MHz ELTs.

When a 121.5/243.0 MHz ELT signal is the only notification that the AFRCC receives of an accident, there is a built in delay of two satellite passes before any action can be taken. The additional satellite pass is required to confirm that the ELT is still transmitting and to resolve the ambiguity problem.

When a 406 MHz ELT is employed the notification time can be reduced by the full time between the 1st alert and merge since the ambiguity of location is usually determined from the first satellite pass. The geostationary satellite capability will provide almost instant notification of the alert, and when the ELT I.D. has been registered in the data base immediate action can be taken by the RCC to begin the Planning/evaluation Phase.

3.2 PLANNING/EVALUATION STAGE

This stage starts (in 121.5/243 MHz ELT missions) when a second satellite pass has allowed a merge of the data to resolve the ambiguity as discussed in paragraph 3.1. In any SAR operation, there is a period of time when information must be evaluated and a course of action decided. Only after this period are resources dispatched to locate and recover survivors. The 406 MHz ELT is expected to effect a significant decrease in the time the AFRCC spends in this phase.

The high incidence of false alarms with the current 121.5 MHz ELT has resulted in operational procedures that call for the RCC coordinator to wait until additional information is received before committing resources. Because of the high number of

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[7] NASA Contractor Report 4330 entitled "Current Emergency Locator Transmitter (ELT) Deficiencies and Potential Improvements Utilizing TSO-C91a ELTs", October 1990

ELT alerts the AFRCC received daily, there can be no SAR resources launched for each ELT alert (even after a merge) without other data to confirm that a real ELT is transmitting and to determine if it is on an airport The RCC investigates the validity of the "alert" by requesting FAA to confirm the presence of an ELT signal with overflying aircraft and by telephone calls to airports within the vicinity of the alert location (for 121.5/243 MHz ELTs this can be within a radius of 20 Km or more). When a possible distress situation is confirmed the RCC determines a search area, and allocates resources.

Three characteristics of the 406 MHz ELT will help to reduce the time spent evaluating and planning a mission: the unique beacon ID, the improved accuracy, and the fact that an alert will be known to come from an ELT and not an interfering source (The ID in the transmission will only allow valid ELT/EPIRB signals to be processed by the system).

3.2.1 Impact of Identification Code on Planning/evaluation Time

The unique identification code assigned to each beacon will rapidly provide "who" is in distress. Reference to beacon registration data will provide the aircraft tail number and identify a point of contact for immediate investigation. With this information, the RCC can determine whether or not the aircraft is accounted for and at the same time query FAA facilities for specific flight information. In coastal areas, the ID will provide immediate differentiation between aviation and maritime alerts, further saving time. The US Coast Guard experience with 406 MHz EPIRBs has been a dramatic improvement in the time taken to launch a rescue mission as well as the reduction in the number of false alarm missions when the EPIRB is registered in the data base.

3.2.2 Impact of Improved Accuracy on Planning/evaluation Phase

The increased accuracy of the 406 ELT will generally reduce the "search area" to less than 12 square Km vs. 1200 square Km for a 121.5/243 MHz ELT. This will enable the RCC to go directly to a particular airport nearest the longitude and latitude of the distress alert given by the satellite system. This will reduce reduce the amount of resources required to search for the aircraft in both distress and non-distress cases.

3.2.3 Impact of Eliminating Interferers as Possible Distress Alerts

Current operations at the RCC using 121.5/243 MHz ELTs require the confirmation by other sources, such as overflying aircraft, in addition to the satellite alert data. This is because of the many false "alerts"[8] that are detected by the satellite from other radiating sources or from noise. Since a valid ELT/EPIRB signal must pass the required ID check, noise or other RF radiation cannot produce false "alerts".

3.3 SEARCH STAGE

The time required to search for and locate a downed aircraft is largely a function of the terrain as well as the area of uncertainty of the location given. The more rugged the terrain, the longer it will take to search the area to achieve a high probability of locating the crash. Independent of terrain, the larger the search area, the more time is required to search it. The size of the area, however, is influenced by the COSPAS-SARSAT system and by the type of ELT employed. When 406 MHz ELTs are in use, the reduction of the search area by a factor of 10 should greatly reduce the amount of search resources needed and the time required to locate the downed aircraft.

4 APPROACH TO DERIVING BENEFITS

The benefits to be derived from the use of 406 MHz ELTs (RTCA DO-204) vice the 121.5/243 MHz ELTs (RTCA DO-183) come from three areas:

- Increased Survivability
- Reduced Search and Rescue Mission Timeline
- Reduction of Resources For Handling False Alarms

4.1 INCREASED SURVIVABILITY

A paragraph by paragraph comparison was made between the specification requirements contained in RTCA DO-183 (121.5/243 MHz ELTs) and DO-204 (406 MHz ELTs) and the improvements/changes made in DO-204 were noted. A Table of this detailed comparison is included in Appendix A.

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[8] A "false alert" is a location generated by the COSPAS-SARSAT system from other than distress transmitters. They are generated by other RF signals in the band or from noise. False alarms are signals from non-distress situations which are radiated by a distress transmitter
A "false alarm" is when an actual ELT or EPIRB is transmitting in a non-distress situation.

Following this comparison each specification improvement was examined by a team of experts[9] to assess the expected improvement in reducing the number of failures for each "Reason for Failure" shown in Table 7 of the NASA ELT study. It was concluded that the DO-204 specification improvements would have an impact in three areas: Fire Damage, Impact Damage and Internal Failure.

Table 4-1 shows the improvements in each of the three ares identified above that can be expected from the use of 406 MHz ELTs. The applicable paragraphs from the ELT comparison table in Appendix A are also indicated Table 4-1.

Table 4-2 shows the projected reduction in the number of failures when the 406 MHz ELT is employed. **By using the ratio of the failure rate and number of failures with 121.5/243 MHz ELTs versus the new value for expected failures the expected ELT survival rate for 406 MHz ELTs is derived at 81%.**[10]

[9] The team of experts consisted of former members of the ELT RTCA committee, including an experienced crash investigator, and an experienced Search and Rescue Operations Officer.
[10] 481/27% = 331/X, where X is the new failure rate of19%, therefore the success rate is 81%.

TABLE 4-1
Expected Additional Improvements from the use of 406 MHz ELTs

EXPECTED IMPROVEMENTS FROM RTCA DO-183 (Table 6 of NASA Study*)			ADDITIONAL IMPROVEMENTS FROM RTCA DO-204	
REASONS FOR ELT FAILURE	**EXPECTED IMPROVEMENT %**	**APPLICABLE* IMPROVEMENTS**	**Expected Improv. %**	**APPLICABLE* IMPROVEMENTS**
1. Insufficient G's	95%	A.7, A.9, B.2, D.8, E.1, E.4		
2. Improper installation	95%	E.1, E.3, E.4, E.5		
3. Battery dead	95%	A.9, E.5, E.6		
4. Battery corroded	50%	A.10, E.5		
5. Battery installation incorrect	45%	A.9, E.2, E.3, E.4, E.5		
6. Incorrect battery	75%	E.3, E.4, E.5		
7. Fire damage	10%	B.3, B.4, D.14, D.15	50%	B6
8. Impact damage	75%	B.1, B.2, B.3, B.4	85%	B1,B3,B4
9. Antenna broken/disconnected	85%	B.2, B.5		
10. Water submersion	0			
11. Unit not armed	98%	A.9, E.1, E.2, E.4, E.5		
12. Shielded by wreckage	10%	A.3		
13. Shielded by terrain	10%	A.3		
14. Internal failure	75%	B.2, B.3, B.4, C.2, D.1, D.9, D.10, D.11, D.12	85%	A11,B1,B3,C2,C9, D1,D4
15. Signal direction altered by terrain	10%	A.3		
16. Packing device still installed	98%	E.1, E.3, E.4, E.5		
17. Remote switch off	100%	E.1, E.2, E.4, E.5		

*** The paragraph numbers listed in the Applicable Improvements column above refer to the ELT Performance Specifications Comparison chart in Appendix A of this report. The paragraphs identified provide the basis for predicting the expected percent improvement for each reason of ELT failure.**

From Table 7 NASA Report
Analysis of 1319 ELT Failures (where data was available) 1983-1987 and Expected Improvement from TSO-C91a ansd Expanded Inspection/Maintenance Program

				ADDED IMPROVRMENT IN PERFORMANCE WITH 406 MHZ ELTS	
REASONS	**# OF ELT FAILURES**	**EXPECTED IMPROVEMENT %**	**EXPECTED # OF ELT FAILURES**	**EXPECTED IMPROVEMENT WITH 406 MHZ %**	**EXPECTED NUMBER OF FAILURES WITH 406 MHz ELTS**
1. Insufficient G's	245	95%	12		
* 2. Improper installation	12	95%	1		
* 3. Battery dead	42	95%	2		
* 4. Battery corroded	2	50%	1		
* 5. Battery installation incorrect	3	45%	2		2
* 6. Incorrect battery	4	75%	1		1
7. Fire damage	280	10%	252	50% (Fire Damage)	140
8. Impact damage	356	75%	89	85% (Impact Damage)	53
9. Antenna broken/disconnected	180	85%	27		27
10. Water submersion	62	0	62		62
*11. Unit not armed	70	98%	1		1
12. Shielded by wreckage	17	10%	15		15
13. Shielded by terrain	9	10%	8		8
14. Internal failure	14	75%	4	85% (Internal Damage)	2
15. Signal direction altered by terrain	4	10%	4		4
*16. Packing device still installed	3	98%	0		0
*17. Remote switch off	16	100%	0		0
Current Total of ELTs not Activated	1,319				
Expected Total of ELTs not Activated			481		331

* Preventable with an Expanded Maintenance/Inspection Program

TABLE 4-1
Expected Additional Performance Improvement Using 406 MHz ELTs

4.2 REDUCED SEARCH AND RESCUE MISSION TIMELINE

Three months of mission folders (484 missions) from the AFRCC were analyzed to develop a baseline for detailed analysis of the current mission timeline for 121.5/243 MHz ELTs. The times for each stage of the mission timeline were plotted in histogram form so that the average time could be computed without being skewed by exceptional cases. These histograms are given in Appendix B. Analysis of the mission folders was also used to validate our understanding of the actions taken at the RCC before a mission was launched. <u>The intent of this portion of the study was to estimate the reduction in the SAR timeline due to the advantages of the 406 MHz ELT and convert this time reduction to increased survivability.</u>

4.2.1 <u>Notification Stage</u>

The notification stage can be divided into two time periods: 1) the time from the distress occurrence to the 1st SARSAT alert and 2) the time between the 1st SARSAT alert and the "merge" time[11]. The 1st period of time is a function of the number of satellites and the geometry of the distress transmitter, therefore, the 406 MHz ELT cannot offer any improvement in the low orbit satellite case, however, the geostationary system can virtually eliminate this time period. The time saving that can be realized with the COSPAS-SARSAT satellite system is in the second time period. Figure 4-2 shows a histogram for the time between the 1st alert and the merge of data from the second pass.

[11] Merge occurs when there are two satellite passes available so that the ambiguity of location can be resolved. No action can be taken by the RCC on the 1st alert because of the ambiguity factor coupled with the large number of false alerts.

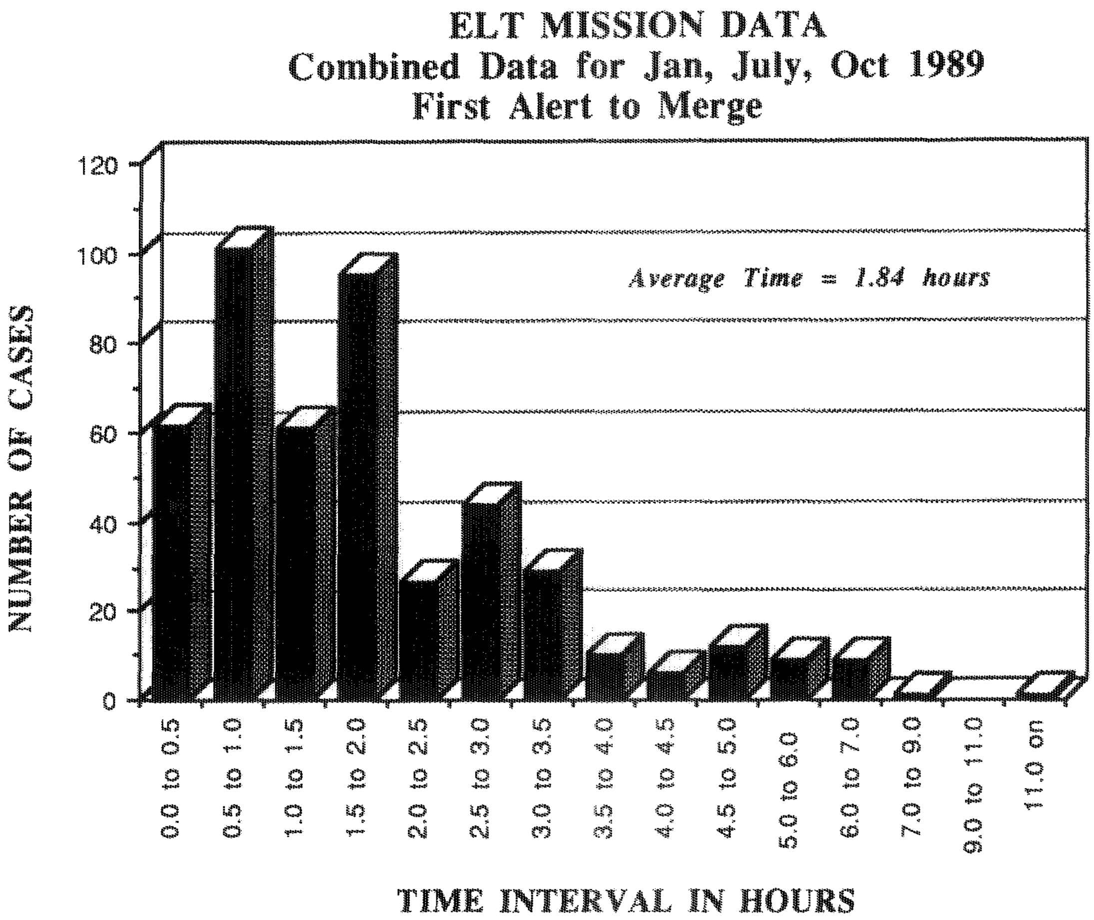

FIGURE 4-2

The average time between 1st alert and "merge" is **1.8 hours**. Since the 406 MHz system resolves the ambiguity over 95% of the time on the 1st pass and since the I.D. in the message identifies the signal as coming from either an ELT or an EPIRB, the RCC can start actively working the mission when the 1st alert is received. As a result the full 1.8 hours can be saved in the 406 MHz system SAR timeline.

4.2.2 <u>Planning/Evaluation Stage</u>

The planning/evaluation stage can be divided into two time periods for analysis purposes. The first time period is between "merge" and when the mission is opened. The 2nd time period is from the time the mission is opened to when the aircraft are launched. The time between "merge" and when the aircraft are launched is a function of the availability of aircraft and other factors that can not be impacted by the 406 MHz